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13. ABSTRACT (*Maximum 200 words*)

Report developed under SBIR contract. The purpose of this SBIR Phase I project was to study the feasibility of developing an automatic test system (ATS) that is designed around the PCMCIA bus. The PCMCIA bus is a technology that allows a computer's capabilities to be expanded through the use of credit card sized devices. The premise for the investigation was that a test system that uses PCMCIA cards would have a high degree of mobility and could be reconfigured to meet different requirements. This would reduce the operation and support costs of electronics systems.

The Phase I research assessed the capabilities of the bus and its suitability for use in an automatic test system. The electrical and mechanical properties of the bus were studied along with its software control requirements. A trade study was also conducted to assess the availability of PCMCIA cards that would be suitable for use in an automatic test system.

All of these efforts were successful. The trade study revealed that a variety of PCMCIA instruments are commercially available. Hardware and software specifications for a PCMCIA based test system have been written. These will guide the development of such a tester during the Phase II effort.

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1.0 PHASE I OBJECTIVES

Military electronic systems have become so complex that they must be tested on computer controlled Automatic Test Systems (ATSs). ATSs are relatively large systems that contain a central computer and a series of test instruments. The computer communicates with and controls the instruments via a high level bus. Because of this, automatic test systems have a semi-rigid architecture that can not easily be reconfigured to meet changing requirements. This limits their usefulness, impacts their mobility and increases the operation and support costs of the electronics systems they support. Recent advances in integrated circuit technology and the introduction of the PCMCIA bus provide an opportunity to develop tightly integrated, highly mobile, automatic test systems that can be configured by the user for different applications.

The goal of this project is to reduce the cost and increase the flexibility of automatic test systems. The premise for the Phase I research is that these goals can be attained by designing an automatic test system that uses the PCMCIA bus for instrument control. The Phase I effort was designed to assess the feasibility of this approach by finding answers to the following questions:

Logistics Issues:

- Will PC Cards be available in sufficient types and quantities to make an automatic test system practical?
- What would be the expected reliability and maintainability of a PCMCIA based test system?
- How does the life cycle cost of a PCMCIA based test system compare to that of exiting Automatic Test Systems?

Hardware Issues:

- Can enough capabilities be placed on a PC Card to fill the needs of an automatic test system?
- How many cards can be controlled by a PCMCIA bus?
- How many cards would be required in an average test system?
- What methods could be used to connect PC Cards to the unit under test in a reconfigurable system?
- What types of technologies can be tested by a PCMCIA based system (analog, digital, RF, etc.)?

Software Issues:

- What language or languages should be used for TPS development?
- What type of control software should be used in a PCMCIA based tester?

2.0 SUMMARY OF RESEARCH

The purpose of the Phase I effort was to determine if a highly mobile, reconfigurable, full-featured automatic test system could be designed around the PCMCIA bus. The PCMCIA bus is a technology that allows a computer's capabilities to be expanded through the use of credit card sized devices called PC Cards. The premise for the investigation was that a test system that uses PC Cards would have a high degree of mobility and could be reconfigured to meet different requirements. This would reduce the operation and support costs of electronics systems.

The Phase I research effort was divided into three segments, hardware, software and logistics. The logistics effort assessed the availability of PCMCIA based instruments which could be used in an automatic test system. It also evaluated the reliability and maintainability of PC Cards and compared the life cycle costs of conventional test systems and a PCMCIA based test system.

The project's hardware component studied the capabilities of the PCMCIA bus and its suitability for use in an automatic test system. The electrical and mechanical properties of the bus were also studied. The software portion evaluated the bus's control requirements, operating system options and the development of tester control and support software.

All of these efforts were successful. The trade study revealed that a surprisingly wide variety of PCMCIA based instruments are commercially available. The architecture for the proposed system was designed as part of the hardware effort and packaging concepts were developed. One of the more surprising findings of the hardware effort was that the latest version of the PCMCIA bus is several times faster then the buses commonly used in automatic test systems (VXIbus and the IEEE-488 bus). This means that a PCMCIA based test system could have testing capabilities not found in conventional test systems. The software effort identified the required control concepts, selected an operating system and developed a plan for supplying the system with a suite of control and support software.

Hardware and software specifications for a PCMCIA based test system were written as part of the Phase I effort. These will guide the development of the test system during the Phase II portion of this project.

3.0 RESEARCH WORK CARRIED OUT

The Phase I effort consisted of a combination of trade studies and engineering analysis which was designed to assess the feasibility of developing a PCMCIA based automatic test system.

3.1 LOGISTICS TASKS

The purpose of the logistics tasks was to determine if PCMCIA based test systems would be a cost effective alternative to existing test systems. This effort was divided into three subtasks.

3.1.1 TASK ONE – AVAILABILITY OF PC CARDS

This task was designed to determine if PC Cards are available in sufficient types and quantities to make their use in automatic test systems practical. This question was answered by conducting a trade study and projecting the availability of cards.

3.1.2 TASK TWO – RELIABILITY AND MAINTAINABILITY

This task assessed the reliability of existing PC Cards through an engineering analysis of vendor supplied data. The expected reliability and maintainability of a PCMCIA based test system was projected from this data. Maintenance philosophy and maintainability predictions for the proposed test system were also developed.

3.1.3 TASK THREE – LIFE CYCLE COST

This task sought to compare the life cycle cost of a PCMCIA based test system to that of existing automatic test systems. While it was not possible to perform a complete logistics analysis of a PCMCIA based system without a firm design, it was possible to use the reliability and maintainability predictions along with projected hardware costs to formulate a meaningful comparison of life cycle costs.

3.2 HARDWARE TASKS

The central purpose of the hardware tasks was to develop the architecture for a PCMCIA based automatic test system. The outcome of this effort was to be a hardware design specification that would define the architecture, packaging and capabilities of the test system.

3.2.1 TASK ONE – PC CARD CAPABILITIES

This task was designed to determine if enough capabilities could be placed on a PC Card to fill the needs of an automatic test system. The issue here is one of size. There is a limited amount of space on a PC Card and a limited quantity of components can be accommodated. The manufacturers of PCMCIA data acquisition cards were contacted as part of this task and the capabilities of existing designs and future designs were analyzed.

3.2.2 TASK TWO – REQURIED CAPABILITIES

This task sought to determine how many PC Cards would be required in an average test system. The instrument requirements of a number of existing TPSs were analyzed to determine maximum, minimum and average ATS instrumentation requirements. This data was then used to estimate the range of PC Cards that would be required. TPSs that were developed by WesTest were used in this analysis and they include TPSs for assemblies and subassemblies form avionics, missile and ground support systems.

3.2.3 TASK THREE – CONTROL CAPABILITIES

The control capabilities of personal computers can restrict the number of hardware additions that can be made. This task studied the control structure of the PCMCIA bus in order to develop an architecture that could accommodate the maximum number of cards specified by Task Two. Power considerations and packaging were also addressed.

3.2.4 TASK FOUR – INTERFACE REQUIREMENTS

The purpose of this task was to develop a method for connecting PC Cards to the other PC Cards and to the unit under test. This task was accomplished by conducting an engineering trade study of existing interfacing methods and the connectors available for use on PV Cards.

3.2.5 TASK FIVE – TESTING CAPABILITIES

This task assessed the potential uses of the PCMCIA tester and evaluated the types of electronic systems it could test (RF, analog, digital, etc.). The task was accomplished by studying the types of technologies available for use in automatic test systems and assessing the feasibility of providing those technologies in a PCMCIA format.

3.3 SOFTWARE TASKS

Software is the most important element in any automatic test system. It is not very difficult to assemble a collection of instruments and wire them into a test system. Developing the software that controls those instruments, converting them into a smoothly functioning system, is a difficult task. This task evaluated the software requirements of the proposed test system and formulated a plan for their development. Two subtasks were accomplished for this effort.

3.3.1 TASK ONE - TPS DEVELOPMENT LANGUAGE

The purpose of this task was to develop the most effective approach to providing the tester with a suite of test software. It was accomplished by evaluating the various languages that could be used and assessing their applicability for use in the test system.

3.3.2 TASK TWO – CONTROL SOFTWARE

This task developed the system's software architecture. Such items as selection of an operating system, interfacing with PCMCIA drivers, operator interface requirements and hardware reconfiguration routines were addressed.

4.0 RESULTS

The Phase I effort was designed to assess the feasibility of developing an Automatic Test System that uses PCMCIA based test instruments. The specific Phase I tasks were accomplished by conducting a number of engineering studies and trade studies. These efforts have produced a set of specifications that will be used to control the development of the test system during Phase II of this project. This section describes the problems that were encountered as well as the results of these efforts.

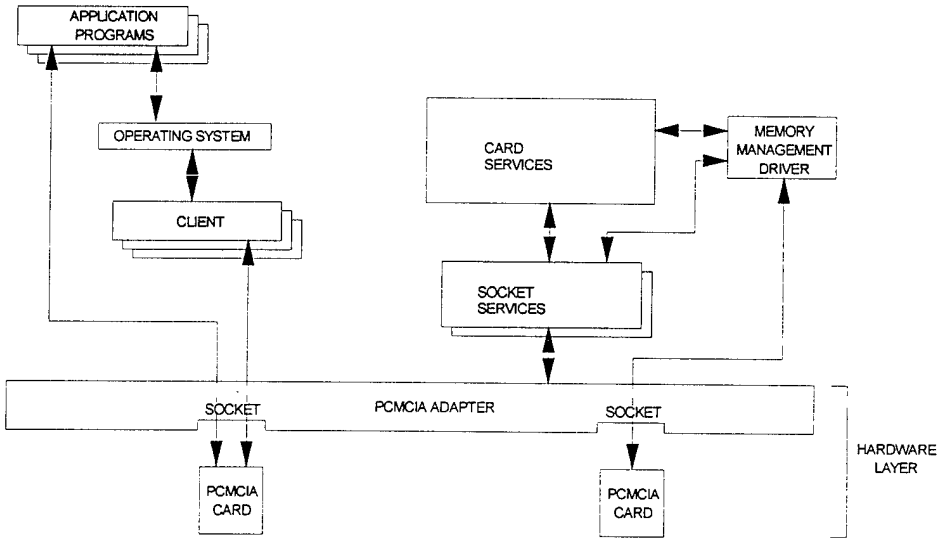
4.1 THE PCMCIA BUS

The Personal Computer Memory Card International Association (PCMCIA) is a consortium of more than 300 manufacturers of computer products. Its membership includes such corporations as Digital, IBM, and National Instruments. In 1991, the consortium published Release 1.0 of the PCMCIA Specification. This is an open, nonproprietary bus standard that allows credit-card-size peripherals (approximately 2.1 by 3.4 inches) to be added to a computer. Release 2.0 of the specification, which was published in 1994, provided the bus with full I/O capability. PCMCIA Cards (or PC Cards as they are often called) can be used to supply virtually any computer function. Modems,

LAN cards, disk drives, sound cards and data acquisition cards are all available. The latest improvement to the bus was announced in 1995. Known as CardBus, it added a number of significant capabilities to the bus.

There are three types of PCMCIA slots; each identified by the thickness of the card they accept. Type I slots, which are 3.3 millimeters thick, accommodate only memory cards. All other card slots are backward compatible because they maintain the same form factor as the Type I card. Thinner cards can be used in slots that are thicker because the card guides remain in the same position. Only the center portion of the slot is thicker. Type II slots are 5 millimeters thick and provide full I/O capabilities. Type III slots are 10.5 millimeters thick. A Type IV card which would be 18 millimeters thick has been proposed but has not yet been approved.

Access to the PCMCIA bus is provided by a 68-pin connector with power and ground pins that are longer than the other pins. When a PC Card is plugged into the connector, the host computer immediately recognizes the card and automatically configures the system for its use. This is known as a Plug and Play capability.



PCMCIA CARD AND SOCKET SERVICES ARCHITECTURE

THE PCMCIA INTERFACE

The ability of PC Cards to work in any manufacturer's computer system is provided by two software services provided by the computer, Socket Services and Card Services. Socket Services provides a "BIOS-like" interface that isolates all higher level software from the particulars of the underlying hardware. Card Services provides a higher-level "read-write-copy-erase" functionality that is media and operating system independent. It also provides a uniform programmer's interface, allowing a card to carry its own device drivers. These functions eliminate the need for a computer system to be configured for a

particular PC Card's capabilities. The card itself supplies the computer with the information it needs to utilize its capabilities. Thus, when a modem is plugged into a PCMCIA compliant computer, the computer is automatically configured to use that particular modem. The same is true for any device that is built in accordance with the PCMCIA specification.

4.1.1 CARD BUS

The 1995 release of the PCMCIA standard added significant capabilities to the bus which are critical to the success of this program. Until this release the PCMCIA bus supported either 8 or 16 bit architecture. The 1995 release added support for a 32 bit architecture. This new capability has been named Card Bus. The first computers with Card Bus slots and Card Bus cards are now commercially available. One of the significant features of the Card Bus is that it is backward compatible, i.e., it can be used with both 16 bit PC Cards and 32 bit Card Bus Cards. Table One contains a summary of PC Card and Card Bus Card differences.

Table One – PC Card/Card Bus Differences	
16 Bit PC Card	32 Bit Card Bus
8, 16 bit interface	8,16,32 bit interface
Non-multiplexed address & data	Multiplexed address & data
Slave only	Master and Slave capability
Asynchronous bus	Synchronous bus (33 MHz clock)
64 Mb of address space	4 GB of address space
20 MB/sec transfer rate	133 MB/sec transfer rate
No error checking	Parity based error checking
Non-cacheable & nonexclusive transfers	Support for cacheable & exclusive transfers
Pulse or level-triggered interrupts	Level triggered interrupts only
Switched Vcc and Vpp lines recommended	Switched Vcc and Vpp lines required
Audio binary tone support	Audio, binary and PWM support
Separate memory-only & I/O interface	Single Interface
Maximum of 8 cards per system	Maximum of 8,192 per system
Hierarchical architecture not supported	Hierarchical architecture supported

4.2 LOGISTICS TASKS

The purpose of the logistics tasks was to determine if PCMCIA based test systems would be a cost effective alternative to existing test systems. The results of these tasks are documented below. Not only would a PCMCIA base system be cost effective, it would be far more flexible and portable than existing test systems. It is impossible to predict the savings realized by the ability to take the tester to the equipment rather than take the equipment to the tester because this has not been possible. Existing equipment still requires huge amounts of power for operation and cooling.

A PCMCIA based system can be battery powered and carried by one person. The ramifications of this are endless. It could impact the maintenance philosophies of the equipment that will be supported as well. The trend today is to build self-test and fault-tolerant electronics into new designs. True portable test capabilities could impact that trend by providing a test port on the prime equipment to allow a portable test system to perform diagnostic testing without any disassembly. There are weight, size, and cost penalties associated with built-in test. By consolidating test-only functions in a portable test system, these penalties can be reduced.

4.2.1 TASK ONE - – AVAILABILITY OF PC CARDS

PCMCIA is an international standards body and trade association with over 500 member companies. The association was founded to establish standards for Integrated Circuit cards and to promote interchangeability among mobile computers where ruggedness, low power, and small size were critical. A trade study was conducted among the manufacturers of PC Cards. From the hundreds of members and manufacturers, the companies that provide the greatest selection of PC Cards that are usable in test systems were chosen for this study. Appendix A contains a compilation of suppliers and PCMCIA products.

The manufacturers of instrumentation cards were contacted and asked to provide their PCMCIA development plans. The only manufacturer with an established timetable for the release of new PC Card products is National Instruments. National is the largest manufacturer of PC Cards, as well as a supplier of VXI test instruments and test software. The fact that National sees the market for these products is very encouraging. It means that many of the smaller manufacturers will continue to follow National's lead in supplying additional test instruments. National has just announced a 51/2 digit DMM, a relay driver card, and plans to offer a 2 channel 20 MHz scope during the second quarter of 1997. Later this year they plan to market an arbitrary waveform generator in a Type II PC Card format, adding much needed stimulus generation capability. Until a full assortment of stand-alone instruments is available, another alternative is offered by National. They have a software suite that they call "Stand-Alone Virtual

Instruments for Windows". This software utilizes a single Analog-to-Digital Converter (ADC) to perform limited measurement capabilities of a signal analyzer, an oscilloscope, a DMM, and a data logger. It uses a Digital-to-Analog Converter (DAC) to perform limited stimulus generation capabilities of an arbitrary waveform generator and a function generator. The capabilities of the "virtual Instruments" are limited by the capabilities of the ADC and DAC used in conjunction with the software. There are many sources of ADC and DAC PC Cards.

An even greater potential for true virtual instrumentation can be realized when multiple PC Cards are used together to provide a wider variety of measurement and stimulus capabilities than are possible with a single ADC or DAC. A virtual Ohmmeter can be constructed using PC Cards available today. A DAC could provide the current source. A switching card tied to a resistor array could provide scaling. An ADC could provide the voltage measurement capability. This combination of PC Cards would provide both two and four terminal resistance measurement capabilities. All that is needed to provide this true virtual instrument is software. The virtual instrument approach will provide additional instrument capabilities without the development of dedicated instruments. This allows greater test flexibility for a given tester configuration than is possible using dedicated instruments only.

The manufacturers contacted during this study are very enthusiastic about the future of PC Card development and sales. This is evidenced by the ever expanding lists of PCMCIA based instruments included in Appendix A.

4.2.2 TASK TWO - RELIABILITY AND MAINTAINABILITY

Reliability and Maintainability specifications for military acquisitions have historically been based upon military standards. ATE reliability has been defined by MIL-STD-781 and MIL-STD-785 with calculations based upon data from MIL-HDBK-217. Maintainability has been defined and calculated in accordance with MIL-STD-470 and MIL-STD-471. DOD Acquisition reform is redefining reliability and maintainability by eliminating the military standards and the introducing performance-based requirements and the use of the use of advanced reliability technologies from non-defense industries.

The Physics of Failure (PoF) is a state-of-the-art reliability engineering technology currently being sponsored by the Army. Studies are being conducted at the University of Maryland to determine how the design, manufacturing techniques and choice of materials can affect a product's reliability. The existing Military specifications assign numerical values to physical features in an attempt to calculate a numerical reliability prediction in mean-time-between-failure (MTBF) hours. Army studies of the radio for the SINCGARS contract have demonstrated that calculated MTBFs, using established military specifications, do not represent actual demonstrated MTBFs. Furthermore, these studies have

shown that there is no correlation at all between the experienced MTBF and the calculated MTBF. Obviously there are factors affecting MTBF that are not taken into consideration by the existing specifications.

4.2.2.1 RELIABILITY

The selected PC Card manufacturers were contacted and asked to supply reliability data. Responses from manufacturers have been very encouraging, with MTBF's ranging from 250,000 hours to over 500,000 hours. Some of the numbers were derived from MIL-HDBK-217 calculations, while others come from the manufacturer's experience with their products. The numbers are impressive regardless of their origin.

Using a PoF approach to PC Card design, the very large MTBF figures obtained from manufacturers appear to be justified. PC Cards are reliable by design. Their small size makes them less susceptible to the effects of shock and vibration. The use of surface mount components with a high contact surface to weight ratio reduces the forces experienced by solder joints under shock and vibration. The use of highly integrated circuits reduces the number of contacts on the PC Card. The totally enclosed design provides ESD protection as well as physical protection.

The overall reliability of the assembled test system is also affected by PoF considerations. Since the total size and weight of the test system will be consistent with its' component parts, higher resistance to shock and vibration and higher overall reliability can be expected. Since there are currently no models available for ATE systems, and a full PoF analysis is beyond the scope of this report, conventional reliability calculations will be used to predict system MTBF. MIL-HDBK-217 reliability calculations derive the reciprocal of system reliability as the sum of the reciprocal MTBFs of each of its components:

$$1/M_{sys} = 1/C_1 + 1/C_2 + \ldots 1/C_n$$

In order to develop a system MTBF figure, a typical system must be defined. The instrumentation for a general-purpose test system capable of making analog and digital measurements is defined below in paragraph 4.2.3.2. The system requires 25 PC Cards with an average MTBF of 350,000 hours per card. The system MTBF, $1/M_{sys} = 25/350{,}000$, or MTBF = 14,000 hours. Comparing this to the equivalent VXI test system requiring 14 VXI cards with an average MTBF of 40,000 hours. The VXI MTBF is $1/M_{sys} = 14/40{,}000$ or MTBF = 2,857 hours.

Using MIL-HDBK-217 reliability calculations the expected reliability of a PCMCIA based test system is five times that of the equivalent VXI based tester. It is expected that using PoF techniques, which more closely represent real world experience, the reliability of a PCMCIA base system would be at least ten times that of a VXI test system.

4.2.2.2 MAINTAINABILITY

Maintainability does not apply to individual PC Cards. Most manufacturers consider a PC Card non-repairable. Their low cost and high reliability does not make troubleshooting and repair of individual cards a cost-effective process. Because of this, no manufacturer was able to supply a mean-time-to-repair (MTTR) for any of their PC Card products. The prediction of the MTTR for a PCMCIA based test system is directly related to the physical design of the tester. Using the hardware specifications in Appendix B and WesTest's experience in designing, building and maintaining VXI based test systems, the estimated MTTR for a PCMCIA based tester is 15 minutes.

4.2.2.3 MAINTENANCE PHILOSOPHY

Due to the low cost of PCMCIA based test equipment, the maintenance philosophy will be to test and repair to the intermediate level of maintenance only. For a portable test system this equates to the circuit card level only for the test instruments and computer. For items peculiar to the tester it means assemblies, such as cable assemblies, power supplies, and personality modules. System calibration will probably require adjustments on some of the individual circuit cards, but if calibration cannot be obtained, the entire PC Card will be replaced.

The life cycle costs of depot, or component level, repair far outweighs the cost of purchasing assembly level spares. A major cost driver in depot level maintenance is the development cost of a Test Program Set (TPS) to support each of the circuit cards that comprise the test system. TPS costs for circuit cards average $50,000. This means that developing the repair capability for a single PC Card would buy over 100 spare cards. With MTBF's predicted in the hundred's of thousands of hours for these cards, it is not cost effective to develop a card repair capability. Since the manufacturers themselves do not repair the cards, manufacturer support is not an alternative. In addition to TPS development costs there are annual software support costs for each TPS, and logistics and spares costs for maintaining component level support.

4.2.3 TASK THREE - LIFE CYCLE COST

While it is not possible to perform a complete logistics analysis of a PCMCIA based system without a firm design, it is possible to use reliability and maintainability predictions for the test system instrumentation to formulate a meaningful comparison of life cycle costs. Because the same control computer and peripherals, and similar control software can be used to control both VXI and PCMCIA instruments, these test system elements are not included in the tables below.

4.2.3.1 EXISTING ATE COSTS

ATE acquisition costs range from $250,000 to over $5M per test system. At the top of the cost scale, existing ATE includes the Army's IFTE, the Navy's CASS, and the Air Force's B2 depot test system. At the bottom of the scale are commercial testers such as WesTest's PK1000/PLUS VXI based test systems. It is not impossible to obtain actual life cycle costs), especially for currently used equipment. In order to develop a model that can be used to compare against a PCMCIA based system, the WesTest PK-1000/PLUS test system will be used.

The choice of the PK-1000/PLUS is based upon the following considerations. It is the lowest cost commercial VXI test system that has demonstrated the ability to support military electronic systems. Actual costs are known because WesTest Engineering Corp. manufactures, supports, and uses the system. It is a PC based system and uses software for development, control, and test programming that is similar to that which will be used on the PCMCIA based system. These factors assure that the comparisons made in this report will be realistic.

Acquisition cost:

PK-1000/PLUS Test System	$500,000
5 years maintenance costs:	
5 year spares cost	$250,000
MTBF	2,857 hr
MTTR, system	2 hr
MTTR, instrument	8 hr

MTBF and MTTR figures are presented in hours only. How they equate to cost depends on the cost of labor and the number of hours per year that the equipment is in operation. Costs will vary but the hour figures can be compared directly.

4.2.3.2 PCMCIA BASED ATE COSTS

The Instrumentation section of a PCMCIA based test system would be at least 5 times more reliable than an equivalent VXI based test system (based upon the calculations shown in 4.2.2.1 above). The initial cost of a PCMCIA based test system would be a fraction of the cost of an equivalent VXIbus based system. Assuming the computer and peripherals cost the same, the instrument costs average 1/10 the cost of VXI instruments as shown in the following table:

INSTRUMENT	VXI		PCMCIA	
TYPE	Model	COST	Model	COST
DMM	HP E1411B	$ 1,683	DAC4050	$ 595
Counter/Timer	HP E1420B	$ 3,450	*	$ 450
Digitizing Scope	HP E1426A	$ 8,100	DAC5102	$ 695
240 pin Static TTL Digital I/O	WesTest DIO (6 VXI Cards)	$53,250	IOP-241 (11 PC Cards)	$2,145
Arb Waveform Gen	HP E1445A	$ 7,650	*	$ 750
Function Generator	HP E1440A	$ 7,300	*	$ 750
Stimulus Switching	HP E1463	$ 1,630	DAQ-ER-8 (3 ea)	$1,185
Test Point Switching	HP E1469	$ 2,525	DAQ-ER-16 (5 ea)	$1,975
DC Signal Source	HP E1418	$ 2,443	DAQ-P16	$ 695
Total		$88,031		$9,240

*Estimated, pricing not currently available

PCMCIA based Test System	$30,000
5 years maintenance costs	
5 year spares cost	$15,000
MTBF	14,000 hr
MTTR, system	0.25 hr
MTTR, instrument	n/a

MTBF and MTTR figures are presented in hours only. How they equate to cost depends on the cost of labor and the number of hours per year that the equipment is in operation. Costs will vary but the hour figures can be compared directly.

4.2.3.3 PCMCIA BASED ATE LIFE CYCLE COST COMPARISON

The table below compares equivalent PCMCIA based and VXI based test systems. The PCMCIA based system shows great potential to become the most portable, least expensive, most reliable test system ever produced.

COST ELEMENT	VXI SYSTEM	PCMCIA SYSTEM
Acquisition Cost	$500,000	$30,000
5 Yr. Spares Cost	$250,000	$15,000
MTBF	2,857 hrs	14,000 hrs
MTTR system	2 hrs	0.25 hr
MTTR instrument	8 hrs	n/a

4.3 HARDWARE TASKS

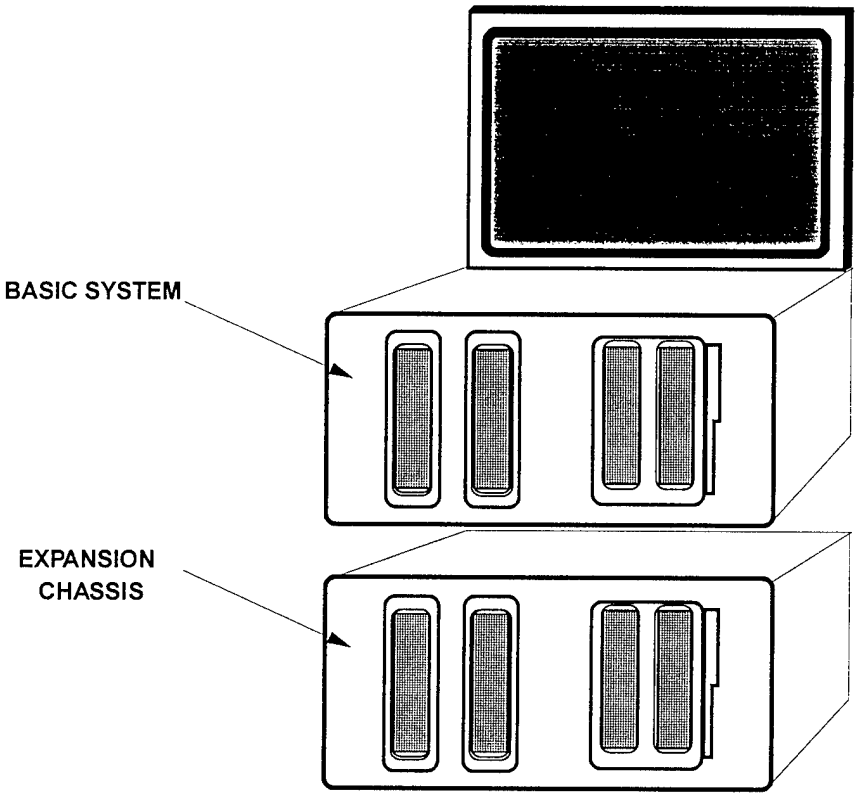
The central purpose of the Hardware Tasks was to develop the hardware architecture for the test system and document it in a hardware design specification. This effort was successful and the specification may be found in Appendix B.

The tester defined in Appendix B exceeds our expectations for this project. The system is low cost, easy to maintain, field reconfigurable and very portable. The tester will be built almost entirely from existing COTS components, will provide excellent testing capabilities and can be powered from a motor vehicle's batteries.

The test system shown below has the following physical characteristics:

- The basic system is 12 inches wide X 7 inches high X 10 inches deep.
- Expansion chassis are 12 inches wide X 6.5 inches high X 10 inches deep.
- Individual chassis will be constructed in a manner that will allow the units to be stacked on top of each other. A mechanism will be provided for securing the units while is the stacked condition.
- The basic system and each expansion chassis will accept up to 32 PC Card or CardBus instruments.
- Virtually any number of expansion chassis may be used.
- The estimated weight of the basic system is < 20 pounds.

- The estimated weight of an expansion chassis is < 15 pounds.
- The system will operate from 12 to 30 VDC power. Battery packs and an AC power converter will be available.
- Operator control is provided by a LCD color touch screen display. Keyboard and mouse connectors are provided.
- The software interface is provided by a Digital Versatile Disk (DVD) drive. DVD disks will be used to store operator instructions, technical manuals and test programs.



The PCMCIA Based Automatic Test System

4.3.1 TASK ONE – PC CARD CAPABILITIES

The requirements of this task were met by analyzing the data provided by PC Card manufacturers. Our team was surprised at the variety of cards that were already available and the rate at which they were being introduced. The basic capabilities of PC Cards and CardBus Cards are most clearly demonstrated by the availability of multifunction cards.

As the name suggests, multifunction cards supply more than one function on a single card. A good example of this are the PC Cards that supply both a fax/modem and a Local Area Network interface on the same card. In the testing area, cards with A/D and D/A converters on one card are available, as are cards that supply both digital and analog test interfaces. Three function Digital Multimeters are also available.

The CardBus specification allows up to eight functions on a single card. However, for the foreseeable future it seems unlikely that more than four functions will be implemented on a card.
This task identified a number of limitations that are imposed by the PCMCIA form factor. All of the limitations are related to the difficulty associated with mounting large components on something as small as a PCMCIA card. The hardware specification in Appendix B will accommodate the solutions to these limitations described below.

- Some functions require components that can not be mounted on the relative thin PCMCIA cards. One manufacturer needed to place relatively large coupling transformers on their MIL-STD-1553 interface card. They solved this problem by adding an extension to the end of the card that is thicker than the portion that is inserted into the PCMCIA slot. This extension remains outside of the card guides and thus doesn't interfere with the operation of the card.

- Another vendor solved a similar problem in order to supply PC Card based relay switching. This company placed the control logic and relay drivers on the PC Card and supplies the relays in a package that is connected to the PC Card via an external cable.

- All of the PCMCIA based instruments currently available have relatively low drive capabilities. For example, the output current capability of one manufacturer's analog to digital converter is 1 Ma. While this is adequate for many applications it is not uncommon for an item to require a higher drive current. This problem can be overcome by providing a means of adding signal amplification to the PC Card outputs on an as needed basis.

- PC Cards do not have the capability of providing either DC or AC power to the unit under test. The VXIbus does not have this capability either and this is not considered a serious deficiency. A number of strategies will be made available for overcoming this problem. Fixed DC supplies will be provided as part of the system's basic capabilities, provisions will be provided for using DC to DC converters to supply additional voltages and a PCMCIA based IEEE-488 interface capability will be provided for controlling IEEE-488 based instruments.

4.3.2 TASK TWO – REQUIRED CAPABILITIES

This task analyzed the test instrument requirements of a large sampling of Test Program Sets and sought to categorize those requirements into three test system capabilities. The results of this task are illustrated in Table Two. It should be noted that the Hi Performance System has analog stimulus and measurement capabilities equal to those found in the IFTE Base Shop Test Station (BSTS) and digital capabilities that exceed those found in the BSTS. It should also be noted that the Intermediate System can be housed in the single CardBus configuration described in Appendix A and the Hi Performance System would only require one expansion chassis.

Table Two – Tester Instrument Requirements

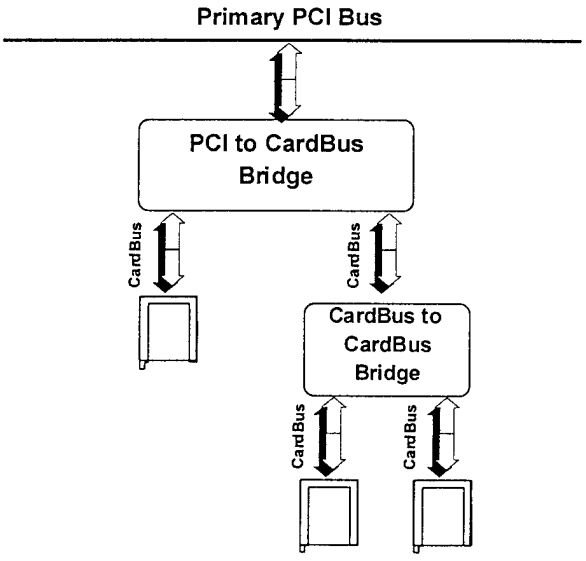
Instrument Type	Basic System	Intermediate System	Hi Performance System
Digital Multimeter	1	1	1
Frequency Counter	1	1	1
Waveform Analyzer (dual channel)		1	1
Synchro/Resolver Measurement		1	1
Synchro/Resolver Simulator		1	2
DC Signal Source	2	4	6
AC Signal source	1	2	4
Digital I/O Testing (24 pins per card)	4 (96 pins)	8 (192 pins)	16 (384 pins)
MIL-STD-1553 Interface (dual channel)		1	1
Stimulus Switching (8 switches per card)	3 (24 switches)	6 (48 switches)	15 (120 switches)
Test Point Switching (16 test points per card)	2 (32 points)	4 (64 points)	10 (160 points)
IEEE-488 Interface		1	1
Totals	14	31	59

4.3.3 TASK THREE – CONTROL CAPABILITIES

When a computer resource needs the services of the microprocessor it communicates that need by sending an interrupt. Standard PC architecture supplies 16 interrupt lines and these must be shared by all of the resources in the computer. PC Cards use these lines and even though some PC Cards can share interrupts, this structure limits the number of cards that can be used in a personal computer based system. This fact was noted in our interim report and several solutions were proposed. The availability of CardBus interface devices provides a much better solution to this problem.

The Peripheral Component Interconnect (PCI) bus was developed to supply personal computers with an improved interface for adding capabilities. PCI is a high performance bus that provides its own interrupt system. It does not communicate with the microprocessor through the normal interrupt system. The PCI bus specification was used to develop CardBus and CardBus uses the PCI protocols. There aren't any interrupt-associated limitations with CardBus. Since PC Cards are backward compatible with the CardBus standard, this effectively eliminates the problem for PC Cards as well.

CardBus also supports a hierarchical bus structured. As illustrated below, this allows one or more busses to be placed below any given CardBus. There can be as many as 256 buses in a CardBus host and each CardBus can support up to 32 cards. Thus a test system could theoretically have up to 8,192 instruments and each instrument could have up to 8 functions. It's clear that there aren't any control limitations imposed by this architecture.

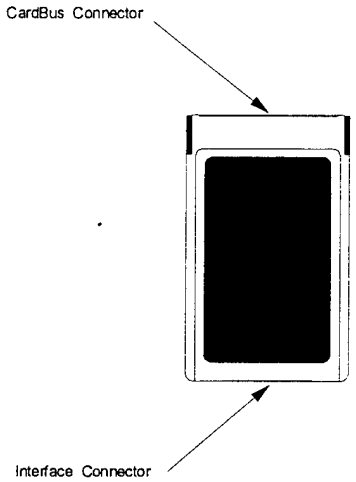


CardBus Hierachical Structure

4.3.4 TASK FOUR – INTERFACE REQUIREMENTS

There are three physical interfaces that must be implemented for this application. PCMCIA Cards to the CardBus interface, PCMCIA Cards to an Interface Panel and Interface Panel to the Unit Under Test (UUT). The manufacturers of PCMCIA products have developed the first two of these interfaces.

PCMCIA Cards were specifically developed for mobile applications. This provides many the key advantages to using them in a portable automatic test system. PCMCIA Cards are inserted into a self-locking slot in the host system. This locking mechanism is so secure that an ejection tab is provided so that the card can be removed. This mechanism will provide the physical interface between the cards and the CardBus connectors.



As noted above, PCMCIA Cards are very thin, thinner than any type of instrumentation previously available. Conventional interface connectors can not be used on these devices. A number of connector manufacturers have met this need by developing a line of molded cable assemblies and a series of surface mount connectors that can be mounted on PCMCIA cards. The connectors most commonly used come in 9, 25 and 33 pin formats and have good electrical and shielding characteristics. Molded cable assemblies are also available form these manufacturers. The interface between PCMCIA cards and the Interface Panel will be accomplished by using molded cable assemblies to connect the card interface connectors to the back of the interface panel. Since most PC Card manufacturers use the same type of output connectors it will be possible to standardize these cable assemblies, simplifying the configuration of the tester.

Friction tabs are commonly used to hold PCMCIA interface connectors in place. It has been our experience that these connectors are easily dislodged. This problem will be overcome by providing the CardBus card rack with retainer clips to hold the cables in place.

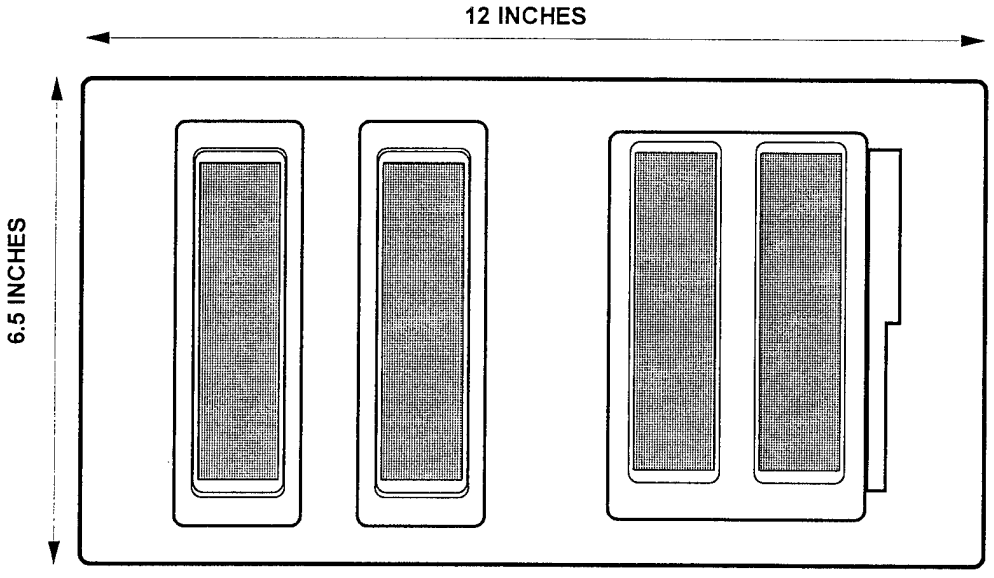
4.3.4.1 THE INTERFACE PANEL

An automatic test system must provide a flexible, trouble free, mechanism for connecting the tester's resources to the unit under test. This is the purpose of the Interface Panel. Interface panels provide these connections either through a series of connectors or by supplying some type of patch panel.

The interface requirements of this tester present some interesting challenges. Conventional connectors and patch panels are too large for this application. Small, high-density connectors are required because the interface must be provided in a relatively small area. The connectors must also be extremely reliable because the connections are changed each time a new item is tested. The final issue is that the interface must provide the capability of augmenting the testers ability to provide the required testing resources. This includes such items as loads, pullup resistors and current drivers.

A relatively new type of miniature, low insertion force, high reliability connectors, meets these diverse needs. Our trade study selected Virginia Panel's TAC interface system for this application. The TAC system provides a high density, pin less interface with high reliability and excellent electrical qualities.

TAC stands for Twin Access Contact and Virginia Panel has made this technology available in miniature patch panels and high-density connectors. Each connector can provide up to 380 pins in a 4.5 X 1 inch package. As shown below, we have provided the tester's interface panel with two connectors and a patch panel. The connectors and the patch panel are wired in series and all of the available resources appear on both interfaces. This approach supplies new levels of flexibility. An interface adapter can be connected to the patch panel or the interface connectors. The patch panel can be used as a personality module or it can be part of the interface adapter and be used with or without the interface connectors. This is a new level of flexibility that is made possible by the availability of these connectors.



INTERFACE PANEL

4.3.4.2 RECONFIGURING A TEST SYSTEM

One of the central goals of this project was to develop a tester that can be easily reconfigured to match the workload. The interface described above makes this possible. The operator accomplishes reconfiguration by following instructions presented on the display panel.

When a test program is executed, the testing requirements are examined and compared against the present configuration of the tester. If they do not match, the operator will be instructed to install the appropriate instruments. This is accomplished by first lowering the hinged interface panel to expose the PCMCIA Cards. Cards are added and removed in accordance with the instructions. Since PCMCIA cards can be "hot-swapped", i.e., installed with power on, the system can monitor the operator's activities, changing the instructions as required.

The operator will also be provided with installation instructions for the cable assemblies that must be installed between the cards and the interface panel. A self-test program that uses a wrap around test adapter will be executed to assure that all connections have been made properly before any UUT testing is started.

4.3.5 TASK FIVE – TESTING CAPABILITIES

For testing purposes, electronic systems can be divided in three general categories, analog, digital and RF/microwave. Analog PCMCIA cards are the most common. This is due to their use in data acquisition. A large number of cards have been developed for these applications. The only type of card that must be developed for testing analog assemblies is a switching card. Relay drivers are already available and this effort will only require packaging relays in the PCMCIA form factor.

PCMCIA based digital test capabilities already exist but they have limited limited capabilities. Until CardBus provided a Master/Slave capability, it was not possible to coordinate the action of individual cards, making it impossible to test large digital assemblies. A PCMCIA based Digital Test Unit (DTU) card set will be developed as part of the Phase II effort. WesTest is well qualified to undertake this effort. WesTest's engineering staff developed a VXIbus based DTU for our line of VXIbus based test systems. WesTest has also developed PCMCIA cards for people with disabilities.

At the present time, it is not feasible to test RF/microwave assemblies on a PCMCIA based test system. PC cards that provide RF capabilities are not presently available. Wireless technology is reducing the size of RF components the capability might be available at a future date.

4.4 SOFTWARE TASKS

The purpose of the software portion of this project was to develop a cost-effective strategy for the development of a suite of control and support software for the PCMCIA based test system. These efforts were successful. The software architecture was designed and a development plan was developed. These efforts are documented in the software specification in Appendix C.

4.4.1 TASK ONE - TPS DEVELOPMENT LANGUAGE

Almost every software language known has been used to control automatic test systems. Some of these efforts were successful; some were not. For this task we assessed the applicability of test languages like ATLAS, general-purpose languages like ADA and C, and graphical programming system like LabView and VEE. The conclusion reached by this analysis is that the language best suited for this application is ATLAS.

Graphical languages such as National Instruments' LabView or Hewlett Packard's VEE provide graphical interfaces which allow the developer to program the instruments in a test system. Consideration is not given in these products to maintaining the test program, documenting the test, or readability of the program. The primary concern is ease of programming. They are not appropriate for use in military and aerospace applications.

Low level programming languages such as ADA and C were written for programmers to develop computer programs that process data or control computer operations in real time. The use of these languages requires a high degree of skill and training. Reliance on library routines to perform standardized functions is heavy. The programmer must have an intimate knowledge of how the computer hardware behaves to us these languages. Maintenance of the program is important and much time is spent documenting program flow, data types and module functions.

ATLAS was developed for automatic test systems. Each ATLAS statement defines test parameters. An ATLAS programmer does not need to concern himself with the details of test equipment operation. Programming is UUT oriented rather than tester oriented. The relationship between the UUT and the test system is defined in a UUT database file. All programming statements that apply a stimulus to the UUT or read a response from the UUT refer to the UUT interface. The ATLAS compiler, using the UUT database, provides the necessary signal routing. The resultant test program is very readable. A maintenance programmer can understand what the test programmer programmed without volumes of test documentation.

For military applications, where the test programmer is usually not the maintenance programmer, and where the test programmer is never the test

operator, the ATLAS language is the clear choice as the most cost effective test language. Another compelling reason for the selection of the ATLAS language is the ease of transporting ATLAS programs between test platforms.

4.4.2 TASK TWO – CONTROL SOFTWARE

This task selected the test system's operating system and developed a plan for providing the tester with a suite of control and support software. The operating system that was selected is Windows 95. This selection was made primarily because of Windows 95's ability to seamlessly control PCMCIA cards. Our engineering team would have preferred using Windows NT because it is a more stable and robust operating system. Windows NT does not currently support plug and play and does not provide power management capabilities, two technologies which are essential to this application. The selection of Windows 95 is considered an interim measure. All software development will be accomplished in a manner that will allow Windows NT to be used when it has the required capabilities.

The test system's control and support software will be developed by rehosting the software systems used on WesTest's VXIbus test systems. This software is already compatible with the Windows 95 operating system and the effort will consist of adapting it to encompass the control of the PCMCIA based instruments. The software programs that will be modified and or rehosted are listed below. A description of their capabilities can be found in Appendix C.

- Windows Based Test Executive System
- IEEE-716 C/ATLAS Compiler
- Guided Probe System (for fault isolation of digital circuits)
- Fault Dictionary System (for fault isolation of digital circuits)
- ATLAS TPS Development Environment
- Test Station Simulator
- LASAR Post Processor
- HITS Post Processor

5.0 ESTIMATE OF TECHNICAL FEASIBILITY

The feasibility of developing an automatic test system which uses PCMCIA based test instruments has been demonstrated by the Phase I effort. All of the elements needed for such a test system have been identified and studied. Guidelines for the Phase II efforts were developed and are documented in the design specifications contained in Appendices B and C.

A number of potential limitations were identified during Phase I. All of these limitations were eliminated by the engineering effort and the proposed test

system will have capabilities that greatly exceed our original expectations. The Phase I effort developed a cost-effective approach to completing the design and development of the proposed test system during Phase II. This will result in a marketable product that is ready for commercialization at the beginning of Phase III.

6.0 COMMERCIAL POTENTIAL

This project has the potential of developing a new generation of automatic test systems. These systems would provide large cost savings and new ways in which automatic test systems can be used. For example, for the first time, a depot test capability can be brought to the field, allowing systems to be tested in their operational environment.

- Because PCMCIA based testers would be smaller and much more rugged than today's systems; they would be ideally suited for use in high mobility, rapid deployment situations.

- Because these test systems could easily accept new capabilities they would not quickly become obsolete, resulting in large cost savings over the life of a weapon system.

- Because the user can reconfigure the testers, they can be used to support a variety of workload, increasing the flexibility of military depots and field level support organizations.

If this project successfully develops the automatic test system described in the appendices, the commercial success of the system is assured. In addition to being smaller, faster and more flexible than existing test systems, a PCMCIA based tester would be less expensive to buy and maintain. It would also be less expensive to develop TPSs on such a system. These are all factors that will contribute to the commercial success of the product.

7.0 CONCLUSIONS

The Phase I research demonstrated that it is feasible to use the PCMCIA bus and PCMCIA based test instruments in an automatic test system. Such a system would have reduced acquisition and maintenance costs, be reconfigurable to match the requirements of the workload, have a very high degree of mobility and reduce the operation and support costs of electronic systems.

APPENDIX A

PCMCIA SOURCES

PC CARD Manufacturers
And Products Used In This Study

Company: ADAC

Address: Woburn, Massachusetts

Telephone: 617-935-3200

Internet Address: www.adac.com

PC-CARD Products:

Multifunction (PCM5516)

Analog Low Cost (PCM5508)

Outputs (PCM55DAC)

Digital I/O (PCM55DIO)

Company: Ines Inc.

Address: 14 Inverness Drive East
Suite C-230
Englewood, CO 80112, U.S.A.

Telephone: 303-649-9024

Fax: 303-649-9025

E-Mail: info@inesinc.com

PC CARD Products:

IEEE 488.2 cards

- GPIB for PCMCIA card, the IEEE488.2 PC-Card for DOS, Windows 3.x, Windows 95 and Windows NT

PCMCIA data acquisition card series

- DAQ i508/i516 High speed data acquisition PCMCIA card (500kHz / 12bit / 8 or 16 channels)

- DAQ i608/616 High speed data acquisition PCMCIA card (625kHz / 12bit / 8 or 16 channels)
- DAQ i148 High performance data acquisition PCMCIA card (600kHz / 14bit / 8 channels)
- DMM i218 High resolution data acquisition PCMCIA card (7.5 digits / 24bit / 1kHz / 16 channels)

PCMCIA digital I/O card series

- DIO i403 Digital I/O PCMCIA card (40 I/O lines / 3 counters)

PCMCIA drives and adaptor boards

- PCMCIA interface cards / bridges for PCI bus or VME bus. Offers up to 4 PCMCIA slots, uses one PCI/VME bus slot.

Company: ComputerBoards, INC.

Address: 125 High Street
Mansfield, MA 02048

Telephone: 508-261-1123

Fax: 508-261-1094

E-Mail: info@computerboards.com

PC-CARD Products:

ANALOG I/O

PRODUCT NAME	DESCRIPTION	Price
PCM-DAS16/12S	16 Channel SE, 12 Bit, 100KHz A/D, Digital 3In-3 Out, Software or External Trigger	$449
PCM-DAS16/12D	8 Differential Channel, 12 Bit, 100KHz A/D, Digital 3In-3 Out, SW or External Trigger	$449
PCM-DAS16S/16	16 Channel SE, 16 Bit, 100KHz A/D, Digital 3In-3 Out, Software or External Trigger	$499
PCM-DAS16S/16	8 Channel Differetial, 16 Bit, 100KHz A/D, Digital 3In-3 Out, SW or External Trigger	
PCM-DAS16/330	16 Channel SE, 12 Bit, 330KHz A/D, Digital 3In-3 Out, +/-5v, +/-10v Ranges	$449
PCM-DAS08	8 Channel, 12 Bit, 20KHz A/D, Digital 3In 3 Out, SW or	$299

PRODUCT NAME	DESCRIPTION	Price
	External Trigger	
PCM-DAC02	2 Channel, 12 Bit Analog Output	$249
PCM-D24C3	24 Digital I/O, 3-16 bit Counters	$149
PCM-COM422	RS232 and RS422 Communications Port for PCMCIA Type2 slots	$149
PCM-COM485	RS485 Communications Port for PCMCIA Type2 slots	$149
PCM-TERM15	15 Position Screw Terminal Board for PCM-DAS08	$49
CIO-MINI37	Universal Screw Terminal for 37 pin D-ConnectorBoards	$49
PCM-C37/33	PCMCIA 33 pin pcm-connector to 37 pin D female connector / 3 feet	$25
PCM-C15-10I	PCM 10 inch cable, 15 pin PCM Connector, other end not terminated.	$25
PCM-C422/232	PCM 10 inch cable, 15 pin PCM Connector, 9 pin connector, RS232 pinout	$25
PCM-C422/422	PCM 10 inch cable, 15 pin PCM Connector, 9 pin connector, RS422 pinout	$25
PCM-C485/485	PCM 10 inch cable, 15 pin PCM Connector, 9 pin connector, RS485 pinout	$25
PCM-CD16S/EXP	PCM-DAS16/12S to EXP16 mux or ISO-RACK08 Cable	$99

Digital I/O

PRODUCT NAME	DESCRIPTION	Avail	Price
PCM-DIO24/CTR3	PCMCIA 24 Digital I/O (8255) PLUS 3 Counters (8254)	In Stock	$149

Communications

PRODUCT NAME	**DESCRIPTION**	Avail	Price
PCM-COM422	PCM-CIA Type II 1COM1, 2, 3, or 4 serial port with RS422 protocol, 16450 UART.	In Stock	$149
PCM-COM485	PCM-CIA Type II 1COM1, 2, 3, or 4 serial port with RS485 protocol, 16450 UART.	In Stock	$149

Company: National Instrument Inc.

Address: 604 Bridge Point Parkway

Austin, TX 78730-5039

Telephone: 512-794-0100

Fax: 512-794-8411

E-Mail: info@natinst.com

Internet Address: http://www.natinst.com

PC Card Products

PRODUCT	DESCRIPTION
PCMCIA-485	PCMCIA-to-RS-485 Interface
PCMCIA-232	PCMCIA-to-RS-232 Interface
PCMCIA-GPIB	GPIB Interface for PCMCIA
PCMCIA-GPIB+ (Analyzer)	Combination GPIB Controller/Analyzer for PCMCIA
PCMCIA-FBUS Series	Foundation Fieldbus Interfaces for PCMCIA
SCXI Overview	SCXI Overview
DAQCard-DIO-24	Low-Cost Digital I/O PC Card
VirtualBench Suite	Ready-To Run Virtual Instruments for Windows 95/3.1
Industrial Automation Overview	
VirtualBench Scope	Stand-Alone Virtual Oscilloscope for Windows NT/95/3.1
VirtualBench DSA	Stand-Alone Virtual Dynamic Signal Analyzer for Windows NT/95/3.1
VirtualBench ARB	Stand-Alone Virual Arbitrary Waveform Generator for Windows NT/95/3.1
VirtualBench FG	Stand-Alone Virtual Function Generator for Windows NT/95/3.1
VirtualBench Logger	Virtual Data Logger for Windows NT/95/3.1
VirtualBench DMM	Stand-Alone Virtual Multimeter for Windows NT/95/3.1
DAQCard-500	Low-Cost Multifunction I/O PC Card
DAQCard E Series Overview	E Series Multifunction I/O PC Cards
NI-DAQ	Data Acquisition Driver Software
DAQCard-4050	5 1/2 Digit Virtual Multimeter Card for PCMCIA
DAQCard-1200	Multifunction I/O PC Card with Analog Outputs
DAQCard-AO-2DC	Low-Cost Analog Output and Current Loop PC Card
DAQCard-516	Low-Cost High-Resolution Multifunction I/O PC Card
DAQCard-AI-16E-4	E Series Multifunction I/O Card
DAQCard-AI-16XE-50	E Series High-Resolution Multifunction I/O PC Card

PRODUCT	DESCRIPTION
DAQCard-700	Low-Cost Multifunction I/O PC Card
FF Monitor	Foundation Fieldbus Monitor Software
LabVIEW Drivers for Industrial Automation	
VXI-DAQ Overview	VXI-DAQ Instrument Module and Signal Conditioning Overview
FF Network Configurator	Foundation Fieldbus Network Configuration Software
SCB-68	Shielded I/O Connector Blocks
SCB-100	Shielded I/O Connector Blocks
DAQPad-1200	Multifunction I/O for the PC Parallel Port
ER-8/16	Low-cost Electromechanical Relay Accessories
DAQPad-MIO-16XE-50	High-Resolution Multifunction I/O for the PC Parallel Port
DAQCard-ER-8/16	Low-Cost Electromechanical PC Card Relay Kit

APPENDIX B

HARDWARE SPECIFICATIONS

1. SCOPE

This specification establishes the performance, design, development and test requirements for an Automatic Test System that incorporates CardBus technology and uses PC Card and CardBus instruments. For the purposes of this specification, a PC Card is defined as a PCMCIA card with a 16 bit architecture that has been built in accordance with version 2.1 of the PCMCIA standard. A CardBus Card is defined as a PCMCIA card with a 32 bit architecture that has been built in accordance with the 1995 release of the PCMCIA standard.

This test system shall incorporate and open architecture design, shall be highly transportable and shall be reconfigurable at the using level. The test system shall provide a general-purpose test capability for analog, digital and hybrid SRUs and LRUs.

2. APPLICABLE DOCUMENTS

The following documents of the exact issue shown form a part of this specification to the extent that they are specified herein. In the event of a conflict between the referenced documents and the contents of this specification, the contents of this specification shall be considered as a superseding requirement.

Test Equipment for use with Electronic and Electrical Equipment, General Specifications for, MIL-T-28800D

PCMCIA PC Card Standard, 1995 Release

Standard General Requirements for Electronic Equipment, MIL-STD-454K

IEEE Standard, Instrument Control Bus, IEEE STD-488

3. REQUIREMENTS

3.1 ITEM DEFINITION

The test system shall provide a test and repair capability for analog, digital and hybrid circuit cards, assemblies and subassemblies. The test system shall be a state-of-the-art system and will utilize PC Card and CardBus technology wherever possible.

3.1.1 Item Diagrams

A physical diagram of the test system is provided in Figure 1.

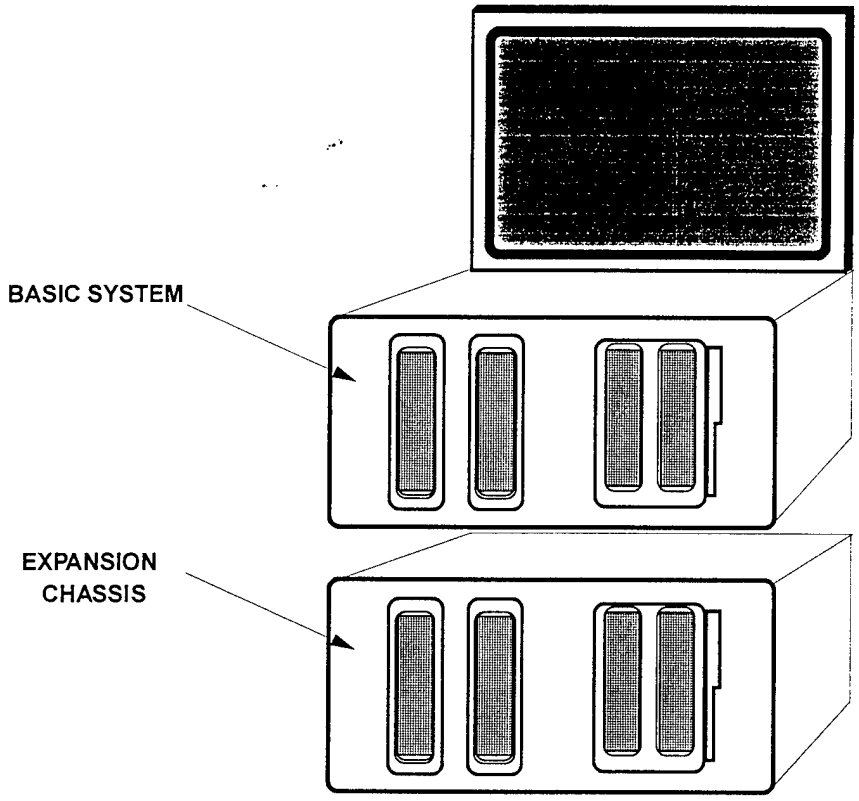


Figure One
PCMCIA Based Portable Automatic Test System

3.2 SYSTEM HARDWARE

The PCMCIA Based Automatic Test System shall use commercial off the shelf (COTS) PC Card and CardBus instruments to provide a general purpose test and measurement capability. The system shall be expandable and a full range of optional capabilities will be available.

3.2.1 Test System Architecture

Test system architecture is illustrated in Figures 2, 3 and 4. The test system shall be controlled by a central computer system. The central computer system shall provide a number of peripheral devices and peripheral interfaces. All instruments in the test system shall be contained in a series of PCMCIA card racks. The central computer shall control the instruments in the basic system via a PCI to CardBus Bridge. Additional PCMCIA card racks shall be accommodated through the use of expansion chassis. Expansion chassis shall be controlled by expanding the CardBus structure. This shall be accomplished by providing each expansion chassis with a CardBus to CardBus Bridge. This is illustrated in Figure Two.

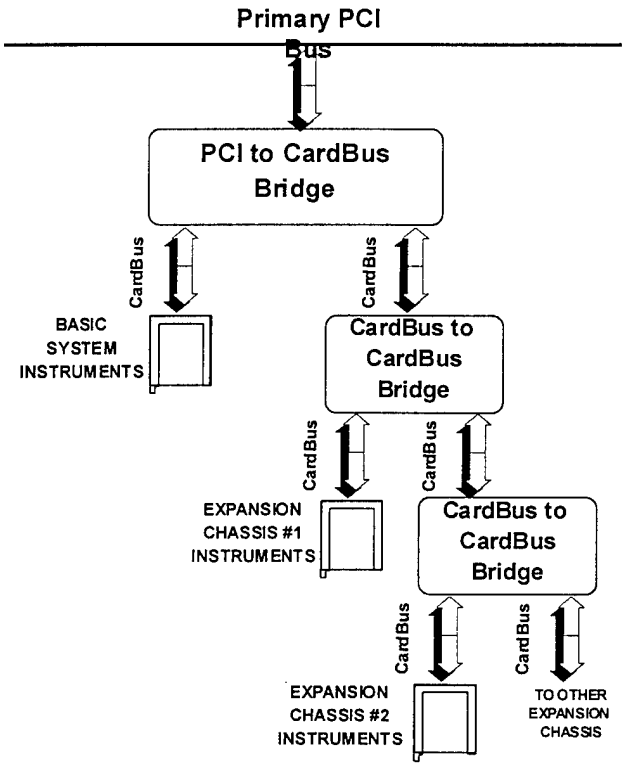


Figure Two – CardBus Control Architecture

The hardware shall be divided into three categories, Basic System Instruments, Expansion Chassis Instruments and the Central Computer Subsystem. The test system's architecture is shown in Figures 3 and 4.

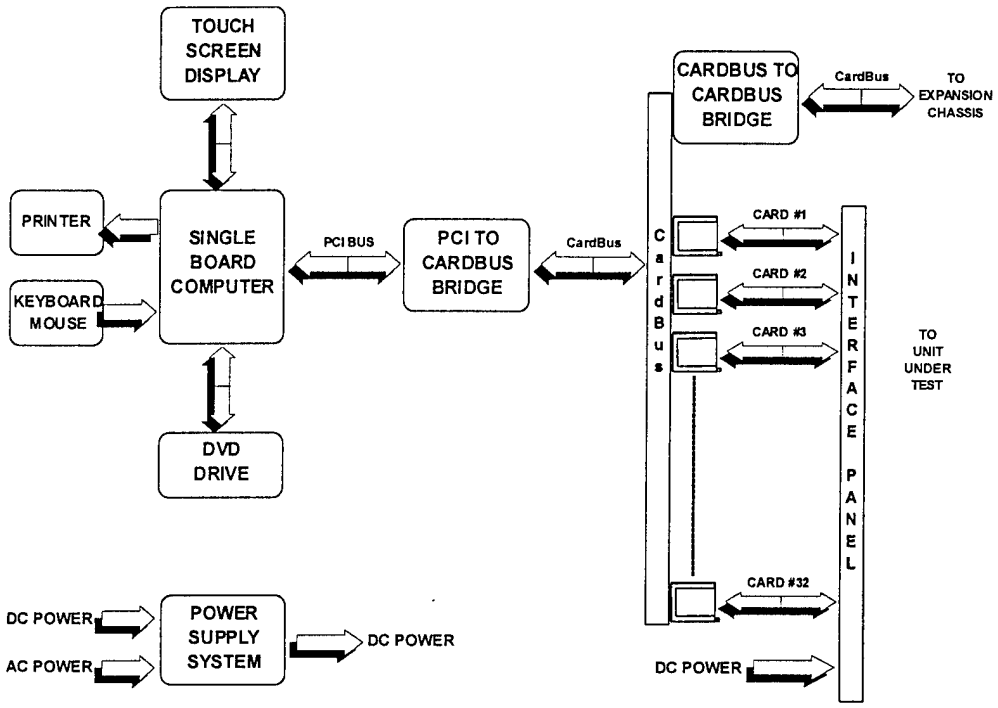


Figure Three – Basic System Architecture

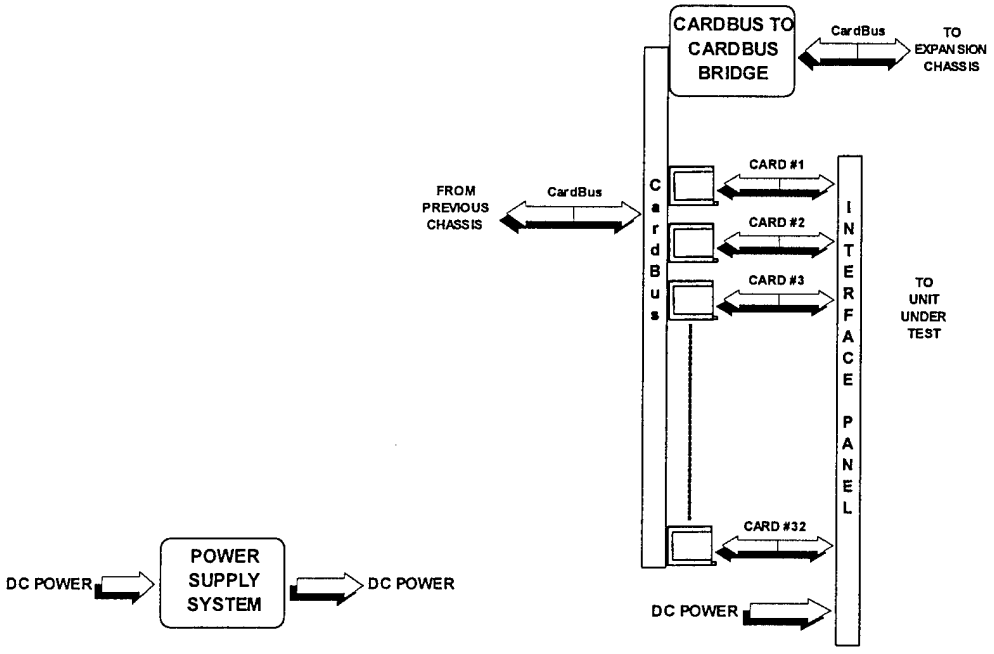


Figure Four – Expansion Chassis Architecture

3.2.2 Packaging

The tester shall be packaged in ruggedized, transportable electronic enclosures that meet the requirements for Type II, Class 5, Style C equipment as defined in MIL-T-28800. The basic system shall be housed in a unit, which measures 12 inches wide X 7 inches high X 10 inches deep. Expansion Chassis shall be housed in a unit, which measures 12 inches wide X 6.5 inches high X 10 inches deep.

The front panel on each unit shall be hinged, allowing the PCMCIA Card Rack to be exposed. The PCMCIA Card Racks shall be recessed 3 inches to allow clearance for cabling and cards with extensions. Double (stacked) PCMCIA sockets shall be used in the card racks. Each card rack shall contain 16 double socket assemblies, providing a system with 32 individual card slots. The double socket assemblies shall be placed 0.5 inches apart to provide clearance for Type III cards and cards which have extensions. The tester's packaging is illustrated in figure 4.

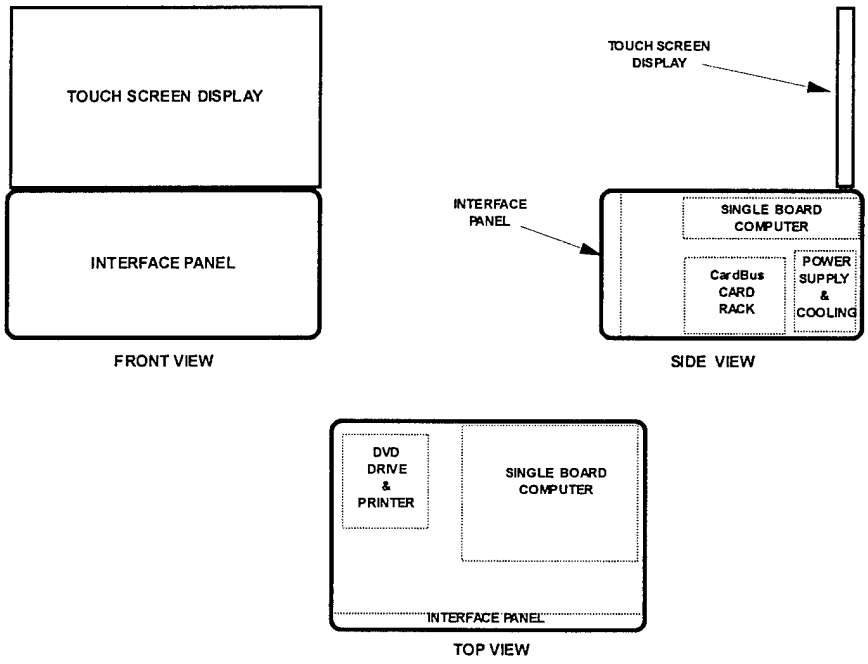


Figure Five – Component Location

3.2.3 Input Power

The test system shall operate from either a DC or an AC power source. When operating from a DC source, the test system shall accept input voltages in the range of 12 to 30 VDC. When operating from AC power, the test system shall operate from 115 Volt or 220 Volt, 50 to 60 Hz, single phase power.

3.2.4 Central Computer Subsystem

A single board computer shall be used for the Central Computer Subsystem. This system shall be compatible with standard IBM PC architecture and use an INTEL Pentium microprocessor. The specifications listed below are considered temporary and will be upgraded, as higher performance boards become available.

- 200 MHz Pentium II Microprocessor
- 32 Mbytes of RAM
- 2 ea. RS-232 Ports
- 1 ea. Centronix Parallel Port
- 1 ea. Keyboard Port
- 1 ea. Mouse Port
- 1 ea. SVGA Interface with 2 Mbytes of Video RAM
- PCI Bus Architecture
- PCI Bus to CardBus Bridge

3.2.5 Instrument Set

The test system shall be constructed in a fashion that will allow it to accept new instruments as they are developed. The system shall be reconfigurable and allow any instrument to be placed in any slot in either the Basic System Chassis or any Expansion Chassis. The initial instrumentation capability of the test system is listed below.

- Digital Multimeter
- Frequency Counter
- Digital Oscilloscope (dual channel)
- Angle Position Indicator
- Synchro/Resolver Simulator
- DC Signal Source
- Arbitrary Waveform Generator
- Digital Test Unit

- MIL-STD-1553 Interface
- ARINC-429 Interface
- General Purpose Relay Switching Card
- Solid State Switching Card
- Measurement Switching Card

3.2.6 Power Supply System

The Basic System and the Expansion Chassis shall contain a DC Power System. This system shall provide power to the PCMCIA connectors. The Power Supply System shall provide four fixed DC voltages to the Interface Connector Assembly. Each of these supplies shall be isolated so they can be placed in series or parallel, increasing the range of capabilities. The voltages that shall be provided are listed below.

+5VDC @ 5 Amperes; Regulation: +/-.1% line, +/-.2% load

+15VDC @ 1 Amperes; Regulation: +/-.1% line, +/-.2% load

-15VDC @ 1 Amperes; Regulation: +/-.1% line, +/-.2% load

+28VDC @ .5 Amperes; Regulation: +/-.1% line, +/-.2% load

3.2.7 Interface Connector Assembly

An Interface Connector Assembly shall be located on the front of the Basic System Chassis and each Expansion Chassis. This device shall provide access to all of the tester's stimulus, power and measurement capabilities. Access shall be provided through the use of standard Virginia Panel, TAC interface devices.

Each chassis shall be provided with two 380 pin Click connectors and one 780 pin MIT Receiver. The connectors and the patch panel shall be wired in series and all of the available resources shall appear on both interfaces. One hundred pins on the receiver shall be reserved for interface device mounted connections. The Interface Connector Panel is illustrated in Figure 5.

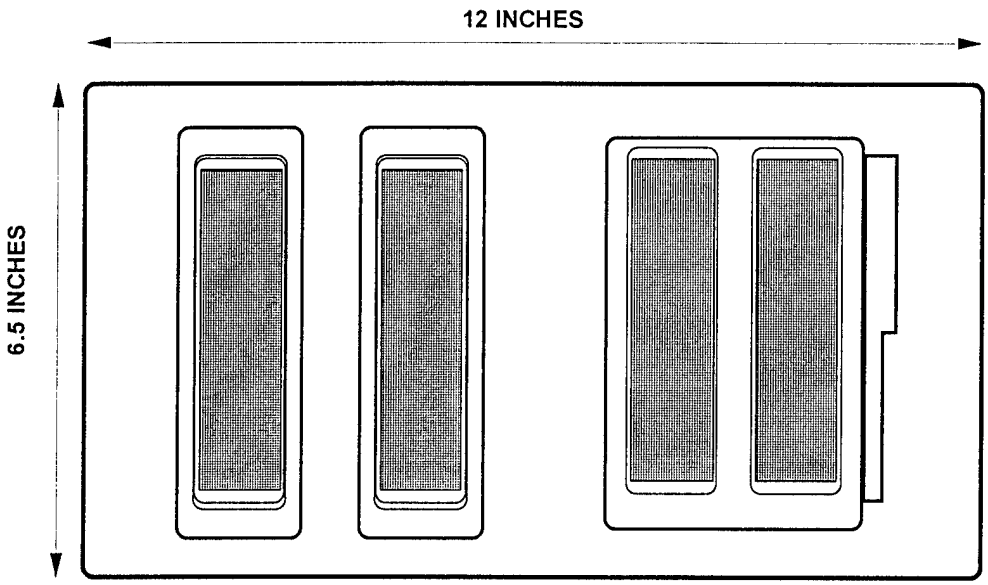


Figure Six - Interface Connector Panel

3.2.8 Interfaces

The test system shall be provided with the following interfaces:

- 12.1 inch color, LCD display with resistive touch screen capabilities. This item shall be used for displaying instructions and test results. It will also supply the primary operator control interface for the test system.

- 48 column printer. This item shall be used to provide a permanent record of test results and tester activities.

- DVD drive. This item shall provide the tester's primary software interface. A 4.2 Gbyte Read/Write capability shall be provided.

APPENDIX C

SOFTWARE SPECIFICATIONS

1. SCOPE

This specification establishes the performance, design, development and test requirements for the control and support software that will be used on the PVCMCIA Based Automatic Test System.

2. APPLICABLE DOCUMENTS

The following documents of the exact issue shown form a part of this specification to the extent that they are specified herein. In the event of a conflict between the referenced documents and the contents of this specification, the contents of this specification shall be considered as a superseding requirement.

- ATLAS Compiler for the PK-1000 Test System, 6000900-16
- ATLAS Programming Manual for the PK-1000 Automatic Test System, 3000010 REV. B
- IEEE Standard, C/ATLAS Test Language, IEEE STD 716
- PCMCIA PC Card Standard, 1995 release

3. REQUIREMENTS

3.1 ITEM DEFINITION

The PCMCIA Based Test System shall operate under the Windows 95 Operating System. The tester shall be provided with an ATLAS Compiler (in accordance with IEEE-STD-716), a Test Executive, a number of utility programs and a self test capability.

3.2 OPERATIONAL Software

Operational software is defined as that software which is executed as part of the normal operation of a test system. The PCMCIA Based Automatic Test System shall be provided with a suite of operational software that shall include and Executive Test System, a Guided Probe System and a Fault Dictionary System.

3.2.1 Operating System

The PCMCIA Based Test System shall use the Windows 95 Operating System. This operating system shall be provided with two additional capabilities. An on screen keyboard control capability shall be provided. This capability shall be developed from the Darci Card on screen keyboard and scanning control software. The second capability shall consist of providing the Card and Socket Services system with the ability to recognize PC Cards and map their interrupts to the CardBus interrupt system.

3.2.1 Test Executive System.

The Test Executive shall read in the test program object code that is output by the ATLAS compiler and control the test station as directed by the program. The Test Executive System for the PCMCIA Based Test System shall be developed from the PK-1000/PLUS Test Executive System.

3.2.2 Guided Probe System.

The Guided Probe System shall provide guided probe fault isolation for digital circuits. The probe shall use data from simulator output files and automatically provides the operator with probing information on the Test Station's display panel. The Guided Probe System for the PCMCIA Based Test System shall be developed from the PK-1000/PLUS Guided Probe System.

3.2.2 Fault Dictionary System.

The Fault Dictionary System shall provide fault dictionary based fault isolation for digital circuits. The system shall use data from simulator output files and automatically provide the operator with information on the Test Station's display panel. The Fault dictionary System for the PCMCIA Based Test System shall be developed from the PK-1000/PLUS Fault Dictionary System.

3.3 Developmental Software

Developmental software is defined as that software which is used for the development and integration of test program sets. The PCMCIA Based Automatic Test System shall be provided with a suite of developmental software that shall include an ATLAS Compiler, an ATLAS TPS Development Environment, a System Monitro, a HITS Post Processor and a LASAR Post Processor.

3.3.1 ATLAS Compiler

The ATLAS compiler shall read in ATLAS source programs and output an intermediate code that is used when testing a UUT. This compiler has been developed in accordance with the IEEE-716 ATLAS specification and features automatic resource allocation and an ITA data base. The compiler may be run on-line or off-line on any IBM compatible computer. The ATLAS Compiler for the PCMCIA Based Test System shall be developed from the PK-1000/PLUS ATLAS Compiler.

3.3.2 System Monitor

The System Monitor shall provide an on-line debug capability for the test system. When invoked, it provides the capability of controlling all of the instruments and switching devices in the test station. The program will be menu driven, provide direct control of the CardBus instruments and supply a readout capability for all of the measurement devices in the test system.

3.3.3 HITS Post Processor

The HITS Post Processor shall read in Navy standard format simulator files and convert them into a format that can be used by the test executive, guided probe, and fault dictionary systems. The Post Processor shall be developed from the PK-1000/PLUS HITS Post Processor.

3.3.3 LASAR Post Processor

The LASAR Post Processor shall read in LASAR Tap simulator files and convert them into a format that can be used by the test executive, guided probe, and fault dictionary systems. The Post Processor shall be developed from the PK-1000/PLUS LASAR Post Processor.

3.4 Maintenance Software

Two levels of maintenance software, Built-In-Test (BIT) and Operational Assurance and Fault Isolation (OA/FI) shall support the PCMCIA Based Test System.

3.4.1 Built In Test

Automatic Built-In-Test (BIT) routines shall be automatically exercised whenever power is applied to the tester. BIT routines shall also be invoked via operator command. Failures will be reported to the operator on the system console.

3.4.2 Test Station OA/FI

The Operational Assurance and Fault Isolation program (OA/FI) shall provide a complete confidence test of the test station's measurement, stimulus, switching and control systems (operational assurance) as well as detailed troubleshooting and diagnostic routines which shall be automatically invoked in the event of a failure (fault isolation). The OA/FI test program shall employ a Self Test Interface Test Adapter to supply a wrap around testing capability, assuring proper operation at the interface panel.